



## Case Report

*Hafnia alvei*: A new pathogen in open fractures

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## ABSTRACT

**Background:** Deep infection following open both bone forearm fractures is a rare complication. Prophylactic antibiotic regimens are targeted at the most common pathogens, which include primarily *Staph aureus* followed by gram-negative bacteria. *Hafnia alvei* is an unusual pathogen that is rarely pathogenic in humans and has never been reported as a cause of infection following open fracture.

**Methods:** We present a 12-year-old male with an open forearm fracture who developed a late deep infection. Cultures grew only *Hafnia alvei*. The patient was treated with debridement, placement of antibiotic beads, and ciprofloxacin.

**Results:** At 6 months following the initial debridement, the patient had no clinical evidence of infection and regained full function of the affected forearm without any residual deficits.

**Conclusions:** This is the first report of deep infection following an open forearm fracture owing to *Hafnia alvei*, a pathogen rarely responsible for human infection.

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## Introduction

The majority of pediatric forearm fractures are closed injuries, and most open fractures are grade I according to the Gustilo & Anderson classification. In a large series of operatively treated pediatric forearm fractures, 11% were open and among these, only 10% were grade II and 5% grade III [1]. Deep infection can occur following open forearm fractures, however, this is fortunately a relatively uncommon complication occurring in 1–5% and mostly affecting higher-grade fractures [2,3]. In the pediatric population, most open forearm fractures are low grade, and there is now substantial evidence that grade I injuries can be treated with antibiotics alone [4,5].

The most common pathogen responsibility for development of late infection among all open fractures is *Staph aureus*, followed by gram-negative organisms such as *E. coli* [6]. In their sentinel paper, Gustilo and Anderson cultured open wounds and demonstrated the most likely pathogens to colonize open fractures, leading to the current antibiotic recommendations that emphasize the role of cephalosporins [6]. In a later series, Gustilo and Anderson found that gram-negative bacteria caused 77% of infections in grade III open fractures, which was significantly increased from their original series including all grades of open fractures [7]. This study and others suggest that open wounds frequently become colonized and infected by nosocomial pathogens, rather than bacteria introduced at the initial injury [7,8].

*Hafnia alvei* is a common gram-negative bacteria found in the environment on plants and vegetables as well as in the gastrointestinal tracts of mammals. It has rarely been reported to cause infection in penetrating soft tissue injury, more commonly

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it has been reported to cause nosocomial infection in immunocompromised hosts. Previously, *Hafnia alvei* has not been reported to cause infection in open fractures.

### Case report

A 12-year-old male sustained a grade IIIA open both bone forearm fracture after falling from an ATV (Fig. 1). He underwent irrigation and debridement 6 h after his injury. Antibiotics were given upon arrival to the ED, which was within 3 h of the injury. He was found to have a grossly contaminated wound with mud, grass and hair present in the soft tissues and within the intramedullary canal of the radius and ulna. Thorough debridement was performed and the wound was copiously irrigated with normal saline. An external fixator was initially placed for skeletal stabilization and the wound was covered with a VAC dressing. The patient returned to the OR two days later for repeat irrigation and debridement, and conversion to internal fixation. Inspection of the wound showed no purulence or further gross contamination, therefore, definitive fracture fixation was performed. This was accomplished with a 1/3 tubular plate on the radius and intramedullary fixation of the ulna. The wound was then closed by delayed primary closure.

Cefazolin was administered prior to the initial procedure and continued for 48 h after wound closure during the second procedure. Weight-based gentamicin (1.5 mg/kg) was given every 8 h from the initial procedure and was discontinued immediately after the wound closure. Additionally, the patient was discharged home on Keflex for an additional 7 days postoperatively. He remained in a long-arm cast for 7 weeks. His wound healed without complication. Serial X-rays were taken at regular intervals (see Fig. 2). At 10 weeks postop, the intramedullary nail was removed from the ulna. The patient gradually returned to full activities and recovered full range of motion.

One year and 5 months after the injury, the patient began complaining of pain on the ulnar border of the forearm (see Fig. 3). He was otherwise healthy without any evidence of fever or illness. On physical exam, he was tender to palpation over the ulna. Laboratory markers were drawn and were not elevated: WBC 8.83 (normal < 12), ESR 13 (normal < 20), CRP 0.18 (normal < 0.76). MRI was performed and demonstrated a sinus tract consistent with chronic infection near the ulna (see Fig. 4).

The patient returned to the OR for debridement. Intraoperatively, a purulent sinus tract that communicated with the ulna was discovered. The ulna was opened with a burr and the intramedullary canal was curetted and thoroughly irrigated. A tobramycin-impregnated bone cement spacer was then placed. He was discharged on oral clindamycin. Cultures were positive for *Hafnia alvei* in isolation. Antibiotics were switched to oral ciprofloxacin 750 mg twice daily based on susceptibilities and continued for 6 weeks. He returned to the OR for irrigation and debridement and removal of the spacer 4 months after the initial debridement.



Fig. 1. AP and lateral radiographs of the forearm at the initial injury.

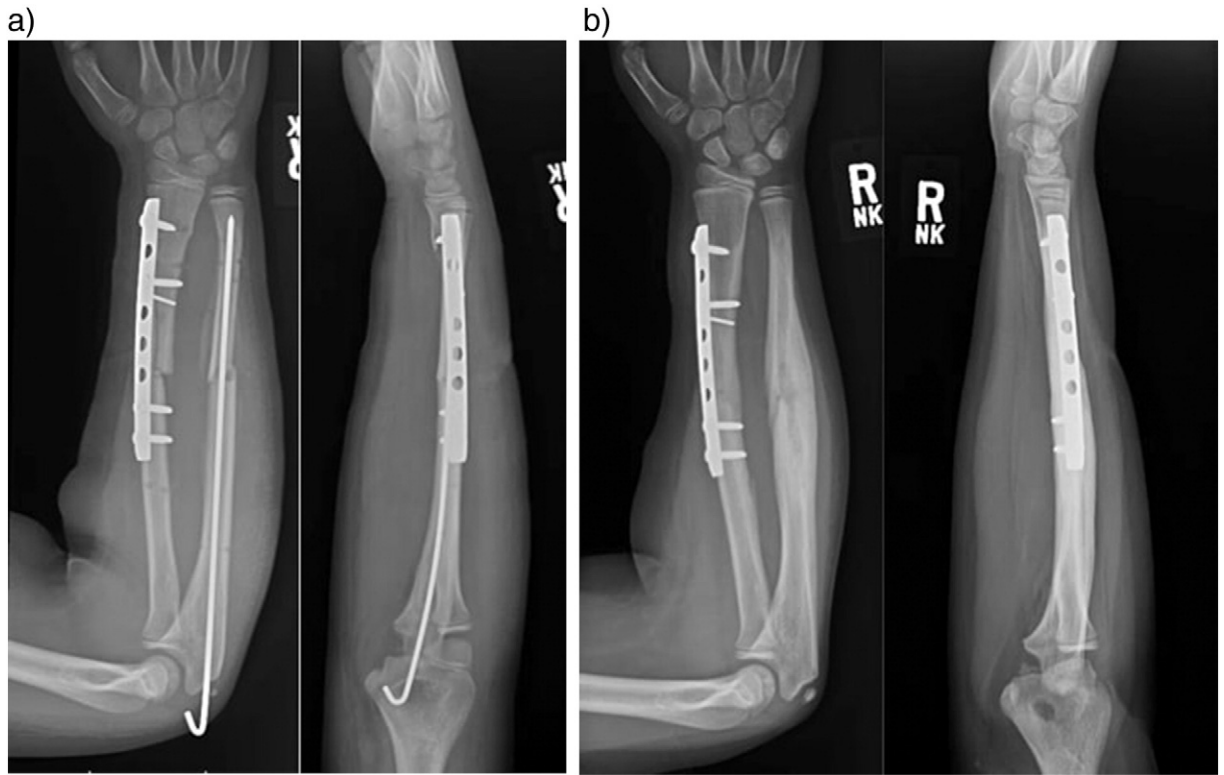


Fig. 2. AP and lateral radiographs of the forearm at a) 2 weeks post-op, and b) at union.



Fig. 3. AP and lateral radiographs of the forearm at the time of infection.

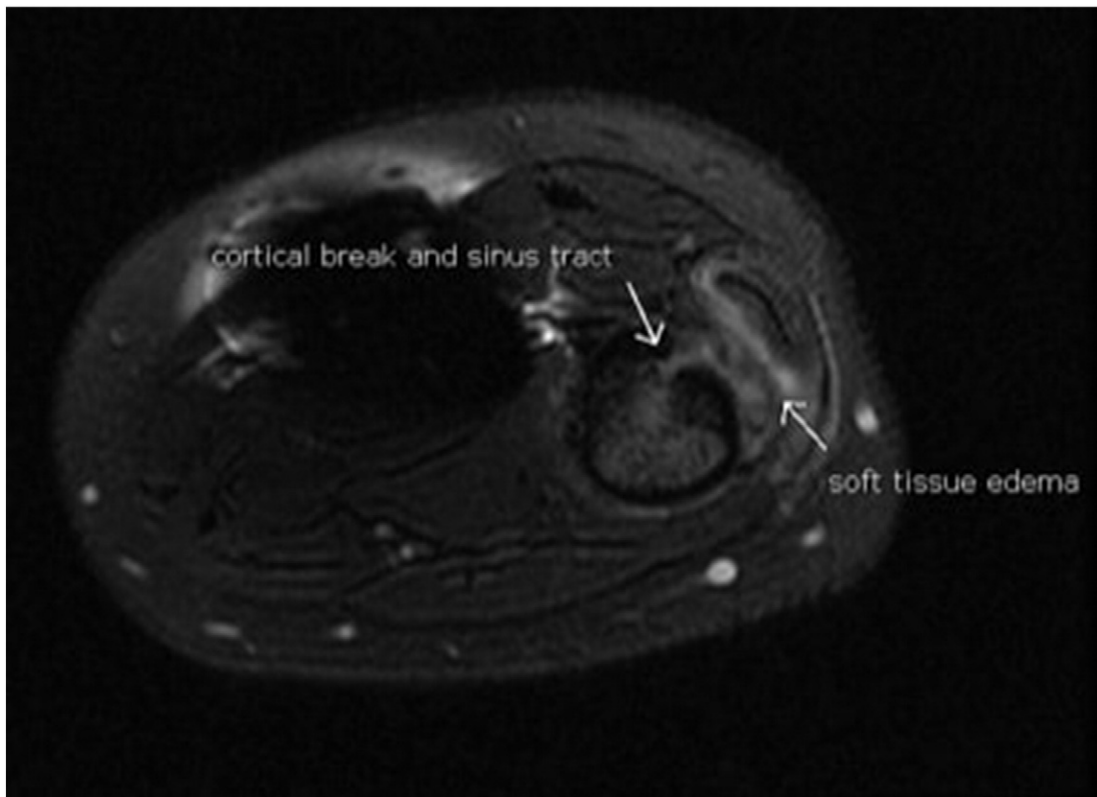


Fig. 4. MRI at the time of infection.

There was no further evidence of deep infection. Six months after the initial debridement, he was seen in clinic with a healed wound, no pain, and full function of the arm.

## Discussion

*Hafnia alvei* is a rare pathogen that has been implicated in both nosocomial and community-acquired infection. It is a gram-negative facultative anaerobic rod bacteria belonging to the family *Enterobacteriaceae*. Although it was first identified in 1954, there is still a lack of information about its most common environment and pathogenic qualities. It can be found in the gastrointestinal tracts of mammals, in refrigerated meats, and on some plants and vegetables [9].

Isolation of *Hafnia* in the clinical setting occurs largely in immunocompromised hosts. According to a large review that evaluated 61 patients, 93.4% had an underlying illness, such as malignancy, recent cardiac or abdominal surgery. In this series, *Hafnia alvei* was predominantly isolated from the respiratory and gastrointestinal tract, with a few cases involving the blood, urinary tract, central venous catheters, and skin. Importantly, *Hafnia* was only recovered in isolation from 25% of the samples, and was felt to be responsible for clinical infection in <10% of cases. This small number of cases equally represented both nosocomial and community acquired infection. Based on antibiotic susceptibilities, the authors recommend treatment with imipenem or a third-generation cephalosporin and an aminoglycoside when clinical infection due to *Hafnia alvei* is suspected [10].

In another series of 36 patients with strictly extraintestinal disease, the majority of the cases were considered nosocomial infections, and 19 cases were pure isolates. The most common underlying medical conditions were diabetes, malignancy, and patients who had recently undergone surgery. All cultures were found to be susceptible to ciprofloxacin, aminoglycosides, and trimethoprim-sulfamethoxazole [11].

Other case reports on clinical infection caused by *Hafnia alvei* exist and include pyelonephritis in renal transplant, pediatric cardiac surgery, and nosocomial pneumonia [9,12–14]. There is a single case of a wound infection caused purely by *Hafnia alvei* developing in an abscess at the site of puncture by a nail gun [15]. There are no reports of open fractures being colonized with *Hafnia alvei* or causing late deep infection.

Osteomyelitis after open fracture typically occurs with the introduction of bacteria at the time of the injury. In some cases, the responsible pathogen may be introduced later, particularly large wounds with more extensive soft tissue injury. For example, Patzakis reported that one-third of patients that developed infection following an open fracture had wounds that were either culture negative at the time of the initial debridement, or contaminated by a different pathogen [8]. This finding suggests that these fractures became infected later by a pathogen not directly introduced during the initial injury. Among this group, 69.2% were

grade III open fractures, implicating that fractures with worse soft tissue injury may be susceptible to this type of delayed introduction of bacteria. Although contamination from the initial injury could be the likely source of *Hafnia* inoculation, it also could have been a nosocomial pathogen introduced later.

Infection by *Hafnia* usually resolves with targeted antibiotic treatment. Recommendations include a third generation cephalosporin and an aminoglycoside, which means that *Hafnia alvei* is covered by typical open fracture prophylaxis. In two series that retrospectively evaluated grade I both bone forearm fractures in the pediatric population treated with antibiotics alone, no patient developed an infection [4,5]. Despite these reported good outcomes, deep infection can still occur. In patients with contaminated higher-grade open forearm fracture, there is a corresponding greater risk of infection despite appropriate prophylaxis. Patients with these injuries should be followed closely and surgeons should be aware of the potential for late-presenting infections. In particular, patients with unexplained pain even with normal laboratory values should be evaluated with MRI for evidence of osteomyelitis. In addition to commonly encountered bacteria, *Hafnia alvei* should also be considered as a potential causative pathogen in these injuries.

The authors report no conflicts of interest.

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